Seabed Variability and its Influence on Acoustic Prediction Uncertainty

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LONG-TERM GOALS

The seabed variability group was incorporated into the ONR Defense Research Initiative on Capturing Acoustic Uncertainty in order to provide a focused investigation into the contribution of seabed inhomogeneity (both bathymetric and geoacoustic variability) to uncertainty in acoustic prediction and detection. My effort is focused on characterizing such inhomogeneity with existing data, with the goal of providing useful input to the acoustic modeling efforts.

OBJECTIVES

The primary scientific objective of my initial work for this project is to formulate a statistical model for bathymetric and geoacoustic variability for the seabed, and to generate from that model realizations that can be incorporated into acoustic modeling efforts.

APPROACH

In the first two years of the program, our seabed characterization efforts are focused on analysis of data collected within the ONR STRATAFORM/Geoclutter natural laboratory on the New Jersey shelf (Figure 1). A number of data sets are available: (1) swath multibeam bathymetry and sidescan data (collected by Larry Mayer as part of the STRATAFORM program; (2) chirp seismic reflection and geoacoustic estimation (data collected and being processed by Steve Schock as part of the Geoclutter program); (3) grab samples and short cores (collected by John Goff and Chris Sommerfield for Geoclutter); and (4) *in situ* velocity measurements (collected by Larry Mayer for Geoclutter).

The swath sidescan data are of particular interest to us because, in the very low slope environment of the continental shelf, backscatter intensity is primarily a reflection of sedimentological properties. Our first task was to investigate the correlation between backscatter intensity and the sediment properties measured (primarily grain size distribution and compressional velocity), in the hope that the highly detailed sidescan map could be used as a proxy for these important sediment properties. The grain size distribution of the outer New Jersey shelf is quite complex, often composed of identifiably separate contributions of mud, sand, and coarse content (either shell hash or gravel). Standard parameterizations of the distribution (i.e., mean, rms, skewness and kurtosis) are inadequate representations of the true nature of the sediments. Rather, we formulated the following parameters to characterize our samples: fine fraction (< 0.063 mm), coarse fraction (> 4 mm), and mean sand grain size (i.e., for grain sizes from 0.063 mm to 2 mm).

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14. ABSTRACT

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Our second priority was to statistically characterize bathymetry and sediment properties, either directly using available data or through the sidescan data as proxy. Data are statistically analyzed by fitting parameterized models to empirical representations of either the power spectrum, covariance function, or semi-variogram (e.g., Goff and Jordan, 1988). Once a statistical model is formulated, any number of independent random realizations can be generated, either unconditioned or conditioned to existing data constraints, using recognized Fourier methodologies (e.g., Goff and Jennings, 1999).

WORK COMPLETED

Measured seafloor properties in the STRATAFORM/Geoclutter natural laboratory have been compared against collocated backscatter data to investigate the possible use of backscatter data as a proxy for measuring spatial variability in sedimentary properties. Statistical characterizations have been produced for bathymetry, velocity and grain size properties. Random realizations have been generated for bathymetry and velocity for use in acoustic modeling work by collaborators in the seabed variability group (Kevin LePage and Bob Odom).

RESULTS

In the correlation analysis of sidescan backscatter and sedimentary properties, we found the following: (1) compressional velocity is primarily correlated to mean sand grain size and fine fraction; (2) backscatter intensity is correlated primarily to coarse fraction; and (3) compressional velocity and backscatter can be correlated only where coarse material is not a factor. Hence, the coarse material (shell hash, gravel) tends to dominate the backscatter when it is present in significant quantities (> ~5%). Unfortunately, this is true over much of the New Jersey outer shelf, and the backscatter map we observe (Figure 1) is largely a map of coarse material content. In contrast, acoustic velocity is not significantly affected by the coarse content, and the sidescan backscatter map cannot be used as a proxy for velocity. Nevertheless, the *in situ* velocity measurements are numerous and with separation distances that cover a range of scales – from 100's of meters to 10's of kilometers. This sort of distributed sampling is well suited to semi-variogram analysis using binning procedures (Goff et al., 2002). A von Kármán model function (Goff and Jordan, 1988) is fit to the velocity semi-variogram in Figure 3, and a 2-D realization is presented in Figure 4.

IMPACT/APPLICATIONS

Realizations of bathymetry and velocity statistical models are being used by LePage and Odom for use in acoustic modeling of the impact of seabed variability on acoustic prediction..

TRANSITIONS

It is hoped that others acoustic modelers within the Uncertainty DRI will also be able to make use of the seabed realizations.

RELATED PROJECTS

The ONR STRATAFORM and Geoclutter programs are providing critical data inputs for this project.

REFERENCES

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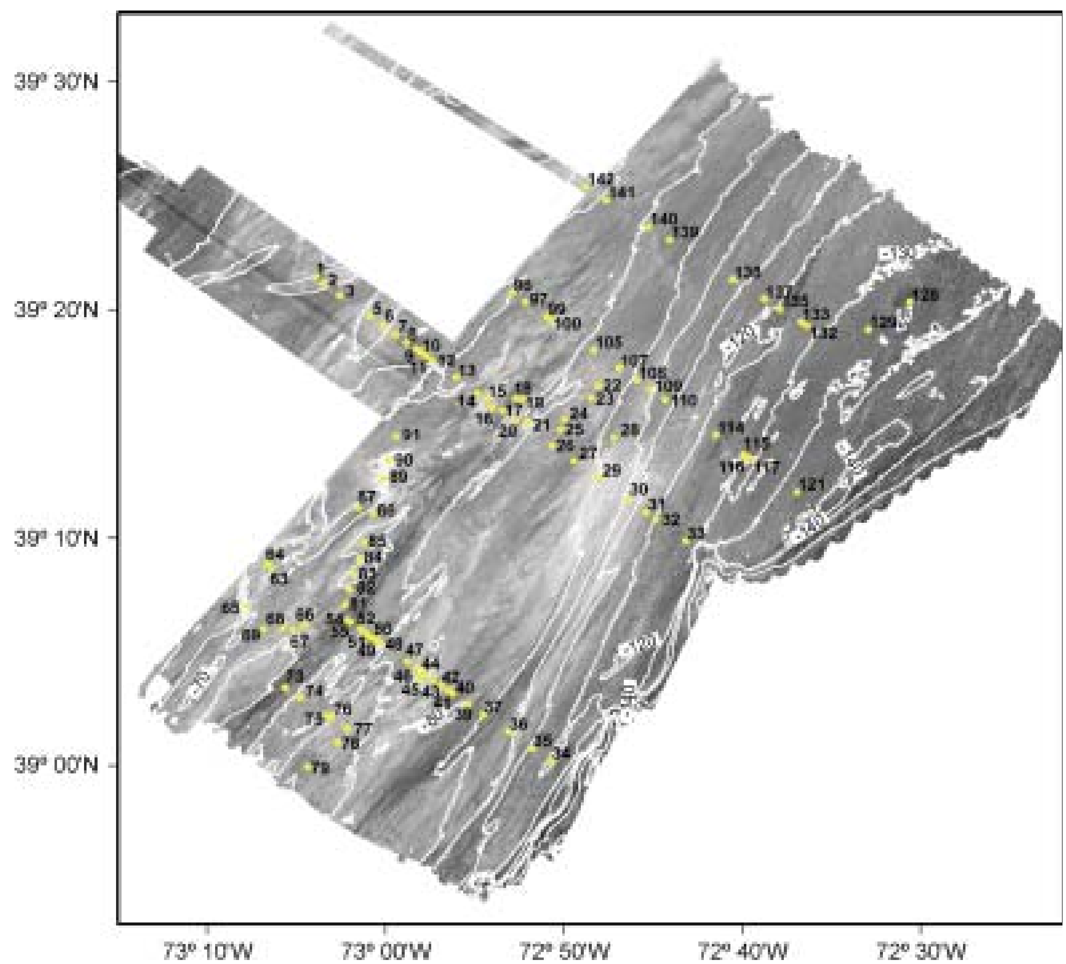

Figure 1. Sidescan backscatter map over the ONR STRATAFORM/Geoclutter natural laboratory, outer New Jersey shelf (higher backscatter = lighter shades), with locations of collocated grab samples and velocity measurements.

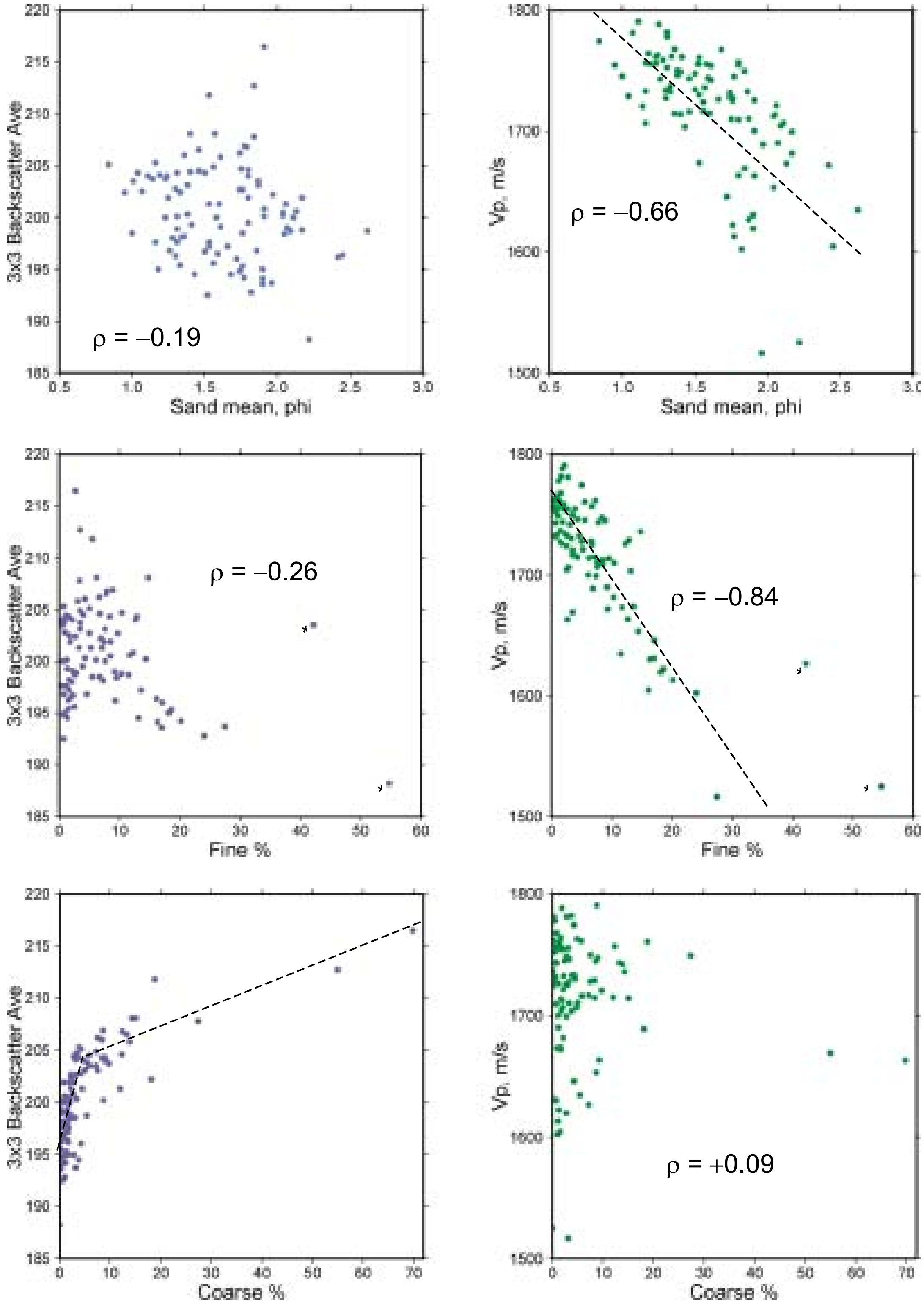

Figure 2. Examples of the correlation analysis conducted for the New Jersey grab sample sediment distribution (mean sand grain size – top; weight % fines – middle, and weight % coarse – bottom), velocity measurements (right panels) and backscatter intensity (left panels). The coarse % vs. backscatter values indicate a non linear trend.

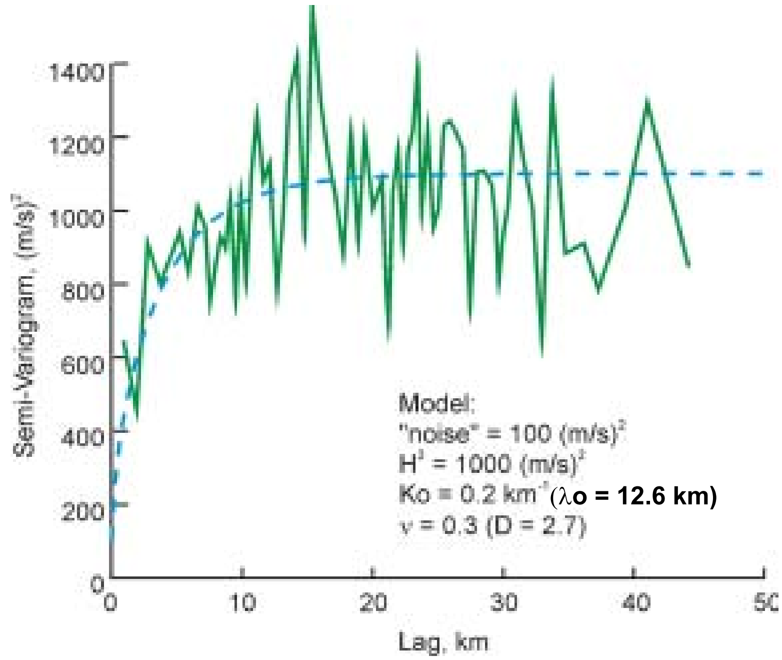

Figure 3. Semi-variogram (green) for velocity measurements conducted within the STRATAFORM/Geoclutter natural lab, with von Kármán statistical model overlain (blue dashed); H^2 is the variance, λ_0 is the characteristic scale, and D is the fractal dimension.

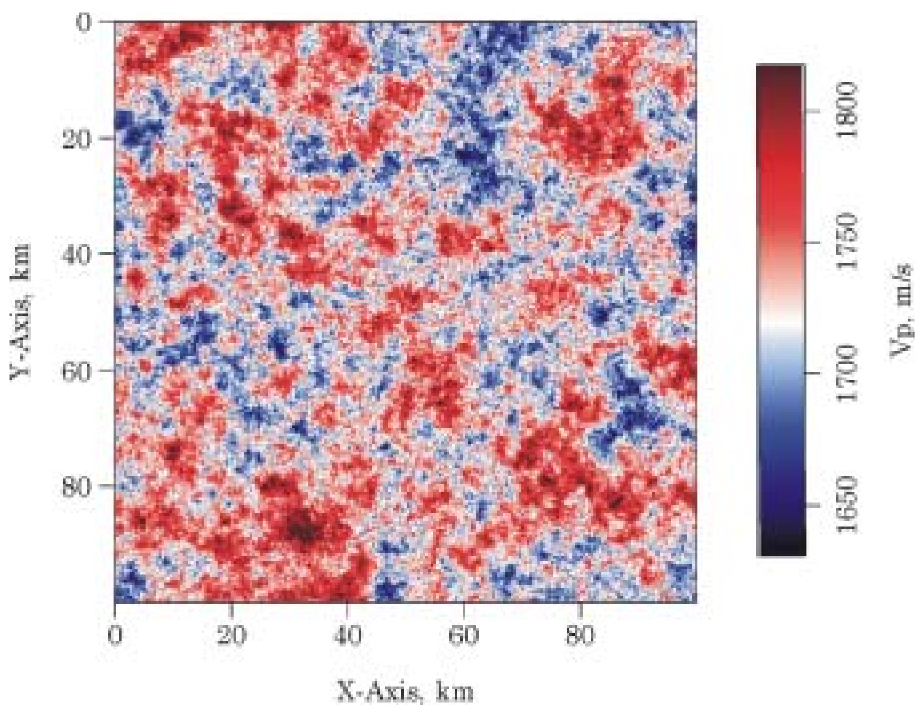

Figure 4. Realization of the von Kármán statistical model for seafloor velocity presented in Figure 3.